

CLAIMS

WE CLAIM:

1. A middleware communication space enabling coordination of one or more distributed applications in a partially connected ad hoc wireless network, the middleware comprising:

a proxy component configured to receive data from the one or more distributed applications;

a protocol agent coupled to the proxy component, the protocol agent configured to monitor metadata for transport and to govern transport of messages in the partially connected ad hoc network; and

a metadata storage component coupled to the proxy component and the protocol agent, the metadata storage component configured to store metadata capable of being transported as a message according to the one or more distributed applications, the middleware communication space providing a bridge between two or more partially-connected networks, the bridge enabling temporary storage of the messages to enable transparent messaging between two or more devices.

2. The middleware communication space of claim 1 wherein the message is in one or more of a SOAP format and a WS series protocol format.

3. The middleware communication space of claim 1 wherein the middleware storage component holds a plurality of the messages in eXtended Markup Language (XML), the messages in a hierarchical structure.

4. The middleware communication space of claim 1 wherein the metadata includes: web service routing protocol (WS-Routing) data that defines routing data; and data appropriate for an extended protocol to provide processing information for the protocol agent.

5. The middleware communication space of claim 1 wherein the middleware communication space provides one or more of message caching, transferring and routing.

6. The middleware communication space of claim 1 wherein the messages are organized into a plurality of data fields including at least one or more of:
 - an expiration time data field identifying the expiration of the message in absolute time such that data are invalid after the identified time;
 - a hop limitation data field providing an upper bound of hops that a message can be transferred, the upper bound decreasing by one after a successful transmission;
 - a timestamp data field providing a absolute time marking creation time of the message;
 - a namespace data field identifying a subspace in which the message is placed;
 - an administration domain data field identifying a domain to which the message is restricted, the administration domain data field defining a physical bound of devices which share a same administration privilege;
 - a relatedness data field specifying a topic to which the message is related, the relatedness providing a relationship attribute to define an action when two or more messages are related to the topic;
 - a priority data field defining a priority of the message; and
 - a property data field providing an extensible component for the distributed application to define application-specific properties with the message. MetaSpace 200 can be configured to support content-based searches of messages via properties.
7. The middleware communication space of claim 6 wherein the messages are organized into at least three of the data fields.
8. The middleware communication space of claim 6 wherein the messages are organized into at least six of the data fields.
9. A method of communicating between a distributed application and a middleware component, the method comprising:
 - issuing a call having a length, the call identifying a message identifier and metadata, the call to remove the metadata from the middleware component; and
 - asynchronously receiving the metadata from the middleware component, the receiving via a virtual shared communication buffer located on one or more mobile

devices, the receiving independent of the existence of a network connection between the mobile device and the distributed application.

10. A hierarchical application programming interface (API) embodied on one or more computer readable media, the application programming interface comprising:

a first set of APIs related to operations of a middleware communication space;

a second set of APIs related to event registration; and

a third set of APIs related to namespace operations, the hierarchical API enabling separation of basic operations of a middleware communication space from security related operations in an environment that allows messaging between disconnected networks using a mobile device, the mobile device independent of simultaneous connection to the disconnected networks.

11. The hierarchical API of claim 10 wherein the first set of APIs includes:

a write function that provides for distributed applications to call a write to insert metadata into the middleware communication space;

a read function configured to read out metadata and removing data from the middleware communication space and remove data and leave the metadata unchanged; and

an enumerate and search function configured to enumerate metadata according to a template of selective criteria.

12. The hierarchical API of claim 10 wherein the second set of APIs includes APIs directed to registration and deregistration via a register function configured to register a handler of one or more events according to a template configured to filter according to type of event.

13. The hierarchical API of claim 10 wherein the third set of APIs is namespace operation APIs including:

a space export and import function to configure which (sub-)space should be shared with one or more devices; and

an enumerate sub-space function configured to provide that a sub-space in the middleware communication space can be enumerated according to a template that

specifies the selective criteria that sub-spaces associated with the distributed application are to enumerate.

14. A computer readable medium comprising:

executable code adapted to perform a function responsive to a call from a component, the function comprising:

one or more operation parameters representing possible operations performable by the component configured to affect a middleware communication space;

one or more event parameters representing event registration for events related to the middleware communication space; and

one or more namespace parameters representing security related operations within the middleware communication space; and

executable code adapted to receive the operation parameters, event parameters and namespace parameters and provide a middleware communication space enabling a mobile device to act as a bridge between one or more disconnected networks transparent to a distributed application.

15. A method for a mobile device to perform as a bridge between two or more networks in a dynamically changing topology, the method comprising:

performing discovery to determine one or more neighbor devices according to a listen and announce protocol;

maintaining storage for metadata including storage for an expected path length;

choosing a neighbor device for receipt of one or more messages, the choosing comprising:

deriving a stochastic model of the dynamically changing topology;

using the stochastic model, evaluating routes for delivering the messages according to the expected path length;

determining a shortest expected path route from the evaluated routes using; and

delivering messages to another device to propagate messages between the networks.

16. The method of claim 15 wherein the mobile device is a node in the topology, the determining a stochastic model including assigning a probabilistic weight representing a probability of a connection between two nodes in the topology.

17. A computer readable medium having computer executable code thereon to perform acts that enable a mobile device to perform as a bridge between two or more networks in a dynamically changing topology, the acts comprising:

- performing discovery to determine one or more neighbor devices according to a listen and announce protocol;

- maintaining storage for metadata including storage for an expected path length;

choosing a neighbor device for receipt of one or more messages, the choosing comprising:

- deriving a stochastic model of the dynamically changing topology;

- using the stochastic model, evaluating routes for delivering the messages according to the expected path length;

- determining a shortest expected path route from the evaluated routes using; and

- delivering messages to another device to propagate messages between the networks.

18. The computer readable medium of claim 17 wherein the mobile device is a node in the topology, the determining a stochastic model including assigning a probabilistic weight representing a probability of a connection between two nodes in the topology.